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OPERATION CHARACTERISTICS OF PULSATING SPRINKLER 60-505 AT DIFFERENT WIND SPEED

(Karakteristik Operasi Sprinkler Pulsating 60-505 pada Perbedaan Kecepatan Angin)

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Abstract

The research about sprinkler irrigation was done in the experimental field and Fluid Mechanical Laboratory of Agricultural Engineering Department, Hasanuddin University. Sprinkler irrigation is a high efficiency irrigation system due to its capability to distribute water uniformly in the exact time. This irrigation system has many types and operation characteristics which different between one to the other. The aim of this research was to study the characteristic of sprinkler pulsating 60-505 and its performance in the field with different wind speed. The research was done by obtaining primary data in the field and measured the wind speed during the operation of the irrigation system on the pressure of 103.44 kPa to 206.88 kPa. It was obtained from the research that the average wind speed was 3 m/second. In this condition, the shape factor of the irrigation system was 0.55 to 0.62 m. The pressure of 103.44 kPa to 206.88 kPa produced spray radius between 3 to 6 m, with application diameter was 6 and 12 m. The research showed that, the performance of the irrigation system was fairly good in the operation with wind speed from 0 to 3 m/second and the pressure of 206.88 kPa. However, in the lower pressure with wind speed over 3 m/second, the irrigation system was less effective.

Keyword: The wind speed, Sprinkler, Pressure, Irrigation system

Abstrak

Penelitian mengenai irigasi sprinkler ini dilaksanakan di lahan Percobaan dan Laboratorium Mekanika Fluida dan Hidrologi, Program Studi Teknik Pertanian, Universitas Hasanuddin Makassar. Irigasi sprinkler merupakan sistem pengairan dengan efisiensi tinggi, karena mendistribusikan air dalam jumlah seragam pada waktu yang tepat. Sistem irigasi ini mempunyai bentuk dan karakteristik operasi yang berbeda-beda. Penelitian ini bertujuan untuk mengetahui karakteristik pencurah tipe Pulsating Sprinkler 60-505 dan kinerja sprinkler pada lahan dengan berbagai kecepatan angin. Penelitian dilakukan dengan pengambilan data primer di lapangan dan mengukur kecepatan angin selama pengoperasian sistem irigasi pada tekanan antara 103,44 kPa - 206,88 kPa. Hasil penelitian menunjukkan bahwa kecepatan angin rata-rata 3 m/detik. Pada kondisi ini, diperoleh shape faktor rata-rata dari sistem irigasi 0,55 m sampai 0,62 m. Pengaturan tekanan antara 103,44 kPa – 206,88 kPa menghasilkan radius semprotan 3 m sampai 6 m dengan diameter aplikasi 6 m dan 12 m. Hal ini menunjukkan bahwa, kinerja sistem irigasi cukup baik jika dioperasikan pada kecepatan angin 0 - 3 m/detik dengan tekanan 206,88 kPa, tetapi pada tekanan yang lebih rendah dengan kecepatan angin di atas 3 m/detik, sistem irigasi kurang efektif.

Kata kunci: Kecepatan angin, Sprinkler, Tekanan, dan Sistem irigasi

INTRODUCTION

Wind speed could influence water distribution to the plants. The high wind speed over 4 m/second in the sprinkler irrigation system will disturb the water distribution to the field. The placement and the choice of sprinkler will influence the uniform distribution of water to the field. With a good design and widely spray distance from the irrigation system to the field, the irrigation system can be designed to distribute water with Uniformity Coefficient more than 90%. The low yearly rainfall and relatively short rain period are the constraint of pattern and planting time. Thus, it is needed to distribute water maximally to the land, although the water will not distribute 100% to the field due to the influence of wind and evaporation

There are many types of sprinkler, such as roll-move, center pivot, and big-gun. The roll-move and center pivot have moving sprinklers, whereas the big-gun is operated steadily. One type of single nozzle sprinkler which produced commercially is pulsating sprinkler 60-505, with the nozzle diameter is 2 mm. This type usually used in vegetable seeding irrigation.

AIMS OF RESEARCH

The research aims were to find out the characteristic of pulsating sprinkler 60-505 and to find out the relationship between wind speed and shape factor.

METHODOLOGY

The research was done in the experimental field and Fluid Mechanical Laboratory of Agricultural Engineering Department, Hasanuddin University Makassar

Instruments and Materials

Research instruments consisted of a sprinkler (pulsating sprinkler 60-505), a water pump, an anemometer, pipes (PVC ½ and 1 inch), a stopwatch, catch-cans, a gauge pressure, measure glasses (50, 500, 3000 ml), plastic hose, buckets, hose connections (T, L, and straight connections), hose caps, saws, a measuring tape, and valves. The materials were water, cable, pipe glue, and ropes.

Research Procedures

The research was done by collecting primary data through these steps:

Preparation steps

Deciding field to be used in the irrigation sprinkler, then the field was plot using ropes. Installation the irrigation system by construct the pipes and connect the pipe into the pump, and also placed the gauge pressure and sprinkler. Placing the catch-cans based on grid pattern (1 m distance between catch-cans) in the sprinkler area. Operating the irrigation system with the selected spray time (15, 30, 45, and 60 minutes)

Sprinkler Test

Pulsating Sprinkler 60-505 Test

Measuring the discharge (Q) and time (t) every 2 minutes. Measuring sprinkler discharge (Q) of pressure gauge in 5 Psi, 10 Psi, 12 Psi, 15 Psi, and 18 Psi. Calculating sprinkler rpm on pressure of 5 Psi, 10 Psi, 12 Psi, 15 Psi, and 18 Psi. Repeated the procedures 3 times.

Field Test to analyze the effect of wind speed to the shape factors

Measuring wind speed by using an anemometer. Calculating sprinkler rpm in the pressure of 15, 20, 25, and 30 Psi. Measuring pressure height (P) and sprinkler spray radius (the diameters). Measuring the shape factors. Measuring the application water volume (water catch-can results) on each can every 15 minutes

Data Calculation

Calculating empirical coefficient (K_d)

$$q = Kd\sqrt{P}$$

Note :

q : sprinkler discharge (liter/minute)

Kd: empirical coefficient / nozzle discharge

P : Sprinkler/nozzle pressure (kPa)

Calculating orifice coefficient (K_o)

$$q = Ko\,A\sqrt{P}$$

Note :

Ko :orifice coefficient

A :area of nozzle diameter (mm^2).

Measuring average wind speed during operating sprinkler irrigation system.

Calculating the shape factor (SF)

$$SF = \frac{di}{dc}$$

Note :

di : inside circle diameter of application area (m)

dc : outside circle diameter (m)

RESULT AND DISCUSSION

Pulsating sprinkler 60-505 characteristics

The pulsating sprinkler is a rotary sprinkler with one 4 mm diameter nozzle. The sprinkler water sprayer angle was 45^0 and resulted in 6-13 l/minute capacity. According to Jensen (1983), the 45^o angle is an appropriate angle for water sprayer. If there is a change in the angle, the diameter sprayer of the rotary sprinkler will be affected.

Relationship at The Test Sprinkler

The test of sprinkler characteristics without operating the irrigation installation was done by using one sprinkler. Fig. 1, shows that there was an increase in the water volume every 2 minutes on each pressure. The sprinkler could produce large water volume and distributed the water evenly. This fact is suitable with Michael (1978), judgment, that the water volume produced from a sprinkler is depended on the pressure. If the pressure is high, then the water volume will be large.

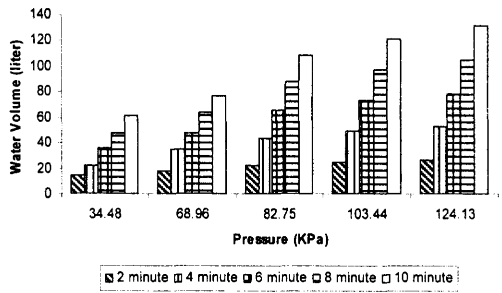

Fig.1. Water Volume and Pressure

The result of sprinkler test was shown in Fig. 2. It is shown that the discharge was upright with the pressure. The measurement showed that the maximum discharge (13.120 l/minute) was on the pressure of 124.48 kPa, and the minimum discharge (6.142 l/minute) was on the pressure of 34.48 kPa. The discharge capacity would be large, if the pressure was maximum.

The graphic showed that the water discharge was not stable, due to the difficulty in arranging the appropriate pressure in the pressure gauge. Jensen (1983), said that the pressure on the sprinkler must be appropriate with the nozzle diameter as it mentioned in Table 1. The high pressure can break the nozzle, if the nozzle is too small. Thus the water particle results will be bad.

The different pressure on the sprinkler would produce different rotation. The maximum sprinkler rotation (9 rpm) was on 124.128 kPa pressure, whereas the minimum sprinkler rotation (3 rpm) was on 34.48 kPa pressure. The sprinkler rotations had a tendency to be constant. If the pressure was high, the rotation would increase. The sprinkler rotation was upright with the pressure. One sprinkler rotation was expected to cover evenly water distribution in the crop land.

Table 1. Size Nozzle diameter and Pressure Relationship

No.	Nozzel Diameter (mm)	Pressure (KPa)
1.	1 - 3	34 - 280
2,	3 - 6	280 - 410
3.	> 6	410 - 650

Source : Christiansen, J. E. (1942)

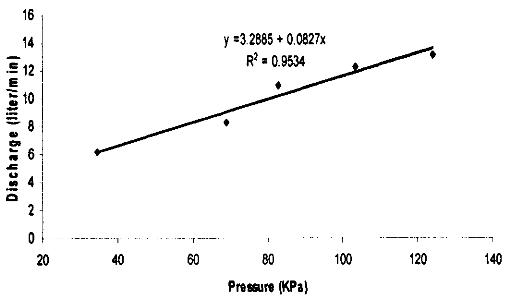

Fig.2. Discharge and Pressure Relationship at The Test Sprinkler

From the measurement of discharge and pressure it was obtained that the empiric coefficient (K_d) was 0.89, and the orifice coefficient (K_o) was 1.12. According to Streeter at al (1995), orifice coefficient is calculated to identify debit flow rate from orifice sprinkler.

Sprinkler sprayer radius

Sprinkler sprayer radius was affected by pressure which was determined by nozzle size. Michael stated that the bigger pressure on the nozzle, the longer sprayer distance (Michael,1973). Fig. 4, showed that the sprayer radius was variety according to the pressure. The pressure used was between 103.4 – 206.88 kPa, according to the nozzle size. To obtain a good sprinkler spraying, the pressure must be increase (Jensen, 1983).

The wet area would be large and the sprayer intensity would be small, if the high pressure is used. Hansen et al (1992), said that low pressure sprinkler produce low sprayer radius and diameter with relatively high intensity of sprayer.

Wind speed

The average wind speed was 3 m/second; the maximum pressure was 206.88 kPa with wind speed range between 0 – 5 m/second. In order to obtain the uniformity of water application and distribution pattern, the measurement was done by arrange the sprinkler pressure on 103.44 – 206.88 kPa according to the diameter of sprinkler (6 – 12 m) every 15 minutes in 1 hour.

The water catch-can result of the sprinkler was very influenced by the wind speed. The difference of Distribution Uniform (DU) in the crops can be caused by the deviation which was very different with the average water catch-can. According to Jensen (1983), the water catch-can decrease on 30^0 temperature is counted up to 1%. Besides that, DU is also influenced with un-uniform catch-can positions, and the fluctuation of wind direction and wind speed (Jensen, 1983).

The high wind speed was occurred in the afternoon. The wind can help water distribution to the plants, but if the speed is high, the plants will lost its water due to evaporation (Anonim, 2007). In the relatively high and fluctuate wind speed, the toleration of effective diameter is 13 m with wind speed range from 0 to 5

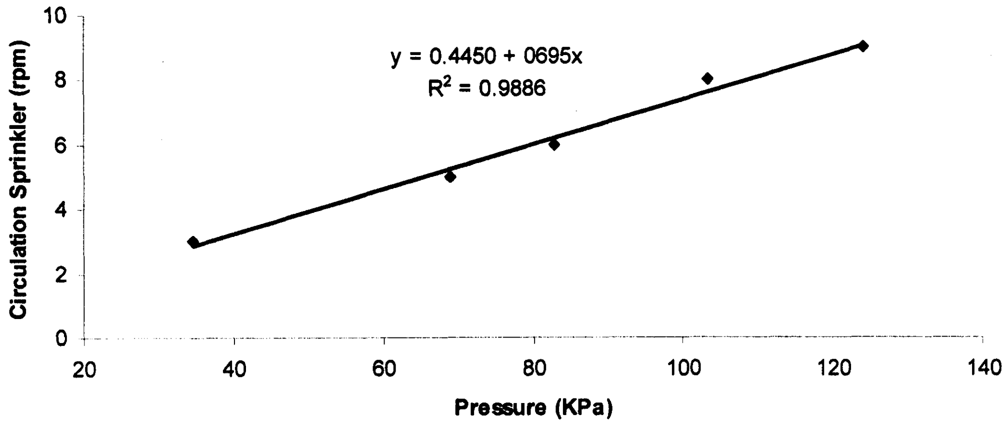

Fig.3. Pressure and Sprinkler Rotations Relationship

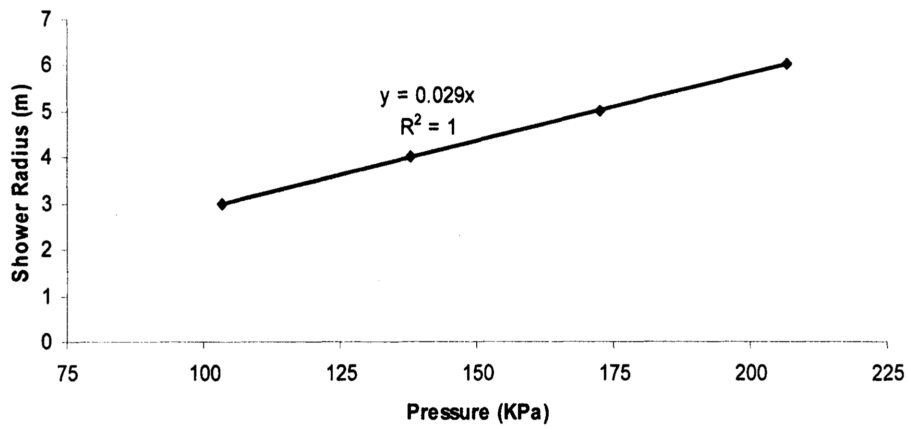

Fig.4. Sprayer Radius and Pressure Relationship

m/second (Jensen, 1983). The pulsating sprinkler 60-505 performance would be effective if it was operated under pressure of 172.4 – 206.88 kPa and wind speed was below 3.60 m/second. The result can be seen in the total catch-can result, which was produced average discharge on 0.124 and 0.230 l/minute.

Shape factor

Shape factor is the pattern or water distribution which is produced by the sprinkler to the land. Fig. 5, showed that, wind speed could influence the water distribution pattern to the land. The high wind speed would change the distribution pattern which was depended on the irrigation system pressure arrangement. If the wind speed was low, the shape factor or distribution pattern to the land would be highest.

Najiyati (1996) said that, water from sprinkler is easily blew by wind, thus affect the water spray pattern and change the wet land pattern which can influence the uniformity of water distribution to the plants.

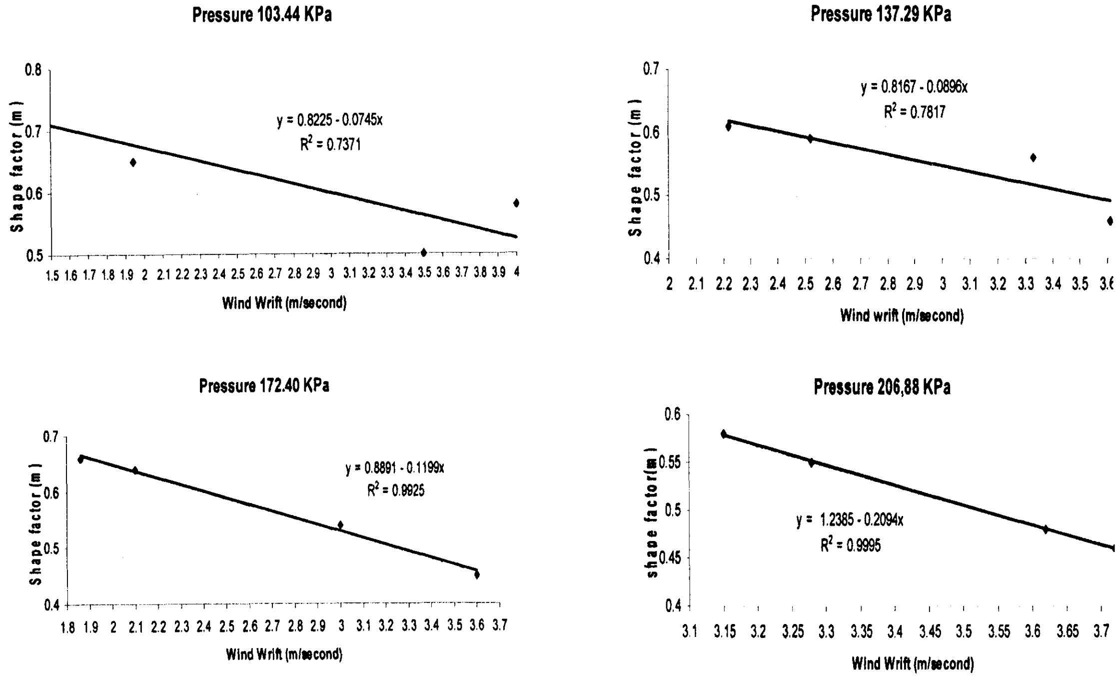

Fig.5. Wind Speed and Shape Factor Relationship at Variation of Pressure

The irrigation system which was operated in the 103.44 kPa pressure and 2.72 m/second wind speed could produce the higher distribution pattern (0.62 m). This fact appropriate with Hansen et al (1992), water spray pattern to the land can be influenced by wind speed which is depended on the pressure, sprinkler distance, and support height.

The average wind speed in the 203.88 kPa pressure was 3.44 m/second, and it could bring water drops distant away from the wet land area. Haman et.al (2003), mentioned that, the low distribution pattern can be influenced with the wind speed and direction, because the water spray particles will be brought faraway from the wet area, as a result the uniformity water distribution was difficult to obtain.

In the pressure of 206.88 kPa with 60 minutes of water spray, the shape factor was very low, because the wind speed and direction was fluctuate which was influenced the distribution pattern. The different distribution for each irrigation time can be caused by climate variation, like sunlight, wind speed and direction (Jensen, 1983).

CONCLUSIONS

The pulsating sprinkler 60-505 was a rotary sprinkler type which had discharge of 6 l/minute on 103.4 kPa (15 Psi) until 13 l/minute on 206.88 kPa (30 Psi). The sprinkler produced spray radius between 3 – 6 m (application diameter 6 – 12 m) and water sprayer angle was 45°. The discharge of pulsating sprinkler 60-505 was upright with the pressure, with empirical coefficient (K_d) was 0.89, and orifice coefficient (K_o) was 1.12. The irrigation system performance was good if it was operated under 0 – 3 m/second wind speed, and 206.88 kPa pressure. Wind speed below 3 m/second produced shape factor higher than wind speed above 3 m/second.

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